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Extreme-Wind Observation Capability for a Next Generation Satellite Wind Scatterometer Instrument

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The ocean surface vector wind information, derived from satellite-based wind scatterometer observations, is one of the essential inputs for operational numerical weather prediction (NWP) services. The local wind speed and direction are retrieved from accurate measurements of the ocean surface backscatter, performed from at least three largely-spaced satellite positions during an over-flight. As a result, each of the wind resolution cells is characterised by a set of radar backscatter coefficients which are associated with their respective observation angles in azimuth and elevation with respect to the cell. The azimuth anisotropy of the backscatter coefficient with respect to the wind direction and its magnitude as a function of the wind speed, as captured in a so-called geophysical model function (GMF), are exploited in order to retrieve a unique vector wind.

The current generation of scatterometer instruments operate at C-band with a single vertical polarisation (i.e. VV), or at Ku-band with VV for the first beam and HH for the second beam. The co-polarised radar backscatter, i.e. VV and to a lesser extend HH, saturate above a wind speed of about 25 to 30 m/s, which imposes a serious limitation on the capability of the existing observation systems. Such a limitation leads, e.g., to misestimation of extreme winds, errors in storm predictions and limitations in weather prediction warnings.

Recently, observations of storm events along the North American coasts by Radarsat-2 and comparisons with in-situ buoy data revealed a high sensitivity of C-band cross-polarised backscatter signal intensity (i.e. VH or HV) with high wind speeds. This prompted the ocean vector wind community to further explore the limit of the cross-polar response. Establishing a new GMF requires accurate in-situ information of the vector wind field together with collocated scatterometer observation data, but these are extremely rare at extreme winds. A more successful collocation approach consists of making use of the wind field information from global ECMWF NWP re-analysis data collocated with Radarsat-2 observations. The result is however affected by inherent NWP model errors and systematic underestimation of peak extreme winds due to limitations in the model spatial resolution. For obtaining independent verification from in-situ wind field information, data from the stepped frequency microwave radiometers (SFMR) instrument flown on board NOAA's Orion P3 'Hurricane Hunter' aircraft were collocated with the available Radarsat-2 observations. A high level of correlation has been confirmed between both the NWP model and the in-situ wind speed and the measured cross-polar radar backscatter up to the extreme wind regime. Further collocated P3 flights are still continuing with the aim of consolidating the GMF and extending its upper limit.

In parallel to the above-described scientific effort for establishing the new GMF and a corresponding wind vector retrieval, an engineering design of a new generation of wind scatterometer instrument was elaborated in the frame of the MetOp Second Generation preparatory programme, jointly undertaken by the ESA and EUMETSAT. These platforms are expected to continue and enhance the services provided by the current EUMETSAT Polar System in the 2020 timeframe and contribute to the Joint Polar System to be set up together with NOAA. The new design features a higher spatial resolution product than the one provided by the ASCAT instrument on board the MetOp series of satellites in orbit, and an additional channel for measuring cross-polarised radar backscatter in order to extend the wind speed dynamic range of the next generation system.

This paper will first present the result of the scientific effort to establish the new GMF for the cross-polarised backscatter. The design of the next generation scatterometer instrument is then described, together with a preliminary assessment of the wind retrieval performance for extreme winds.